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MODEL TEST MODEL

by

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MODEL TEST MODEL

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ABSTRACT

This report documents an investigation into using operational field test data as inputs into the Janus high resolution model using a process that is collectively known as Model Test Model (MTM). After a description of MTM, the report describes the Javelin Initial Operational Test and Evaluation (IOTE) which provided the field data. An overview of the Javelin antitank weapon and the field instrumentation used to capture IOTE data is presented. The report highlights the problems associated with terrain effects and Ph and Pk values when incorporated into the Janus model. A description of Janus modeling modifications required to portray the Javelin is discussed. The report concludes with suggested improvements to enhance the MTM process.

1 Introduction

The Model-Test-Model(MTM) process is a concept that intends to leverage the advantages of simulation modeling into improved acquisition testing. The concept envisions five distinct phases: Long Term Planning, Pretest Modeling, Field Test, Post Test Modeling and Model Validation/Accreditation. This report discusses the use of the Janus combat model using field test data from the TEXCOM Experimentation Center's (TEC) Javelin Antitank Initial Operation Test and Evaluation (IOTE). Janus is currently the Army's premier high resolution combat model and widely used throughout the analytic community. TEC's instrumented field test range at Fort Hunter Liggett is likewise the Army's most complete test range for capturing operational test results. This tandem use of Janus with TEC data should produce model results closely matching field trial performance.

The structure of this report is intended to serve as a guide for incorporating field test data into a high resolution model. After a brief discussion of the MTM concept, the Javelin antitank system and TEC's instrumentation, the implication of the terrain data will be discussed. As field test data is very sensitive to Line of Sight (LOS) calculations, adjustments must be made to the database to match the actual field terrain. Next, the report will examine the effect of Probability of Hit/Probability of Kill (Ph/Pk) values used in the field experiment and their modeling implications. Finally, operational modeling of certain characteristics specific to the Javelin antitank system will be presented as representative of adjustments needed to simulate new weapon systems.

2 Model-Test-Model

MTM conceptually intends to use high resolution combat models to both simulate and replicate actual field operational tests. By careful use of the model, insights may be achieved by combining the simulation data with actual field trial data. MTM is divided into five phases.

The Long Term Planning Phase identifies responsibility among the interested organizations. The relationships are formalized by the creation of a Memorandum of Agreement (MOA) which maps resource commitments, organizational control and expected products.

Pretest Modeling's goal is to improve test design by addressing issues of efficiency and effectiveness. This can be accomplished in two ways. First, prior to the actual field test, test planners have an opportunity to preview the new system to determine the best tactics to be used in a given scenario. Secondly, the scenario planners can predict the ability of test scenarios to capture the required data to evaluate the test objectives. This process can provide insights into possible outcomes during Operational Testing. Pretest Modeling also identifies the model weaknesses and points out areas for model improvement.

During the Field Test Phase the modeler must play an active role in the data gathering process. The insights gained during trials provide the modeler with information on the actual conduct of testing and the rationale for data collection and verification. Most tests convene a Data Analysis Group (DAG) or Scoring Conference whose responsibility is to validate the collected data. The modeler should be attuned to the process used in this validation

procedure since he may face the same questions as to data acceptability while analyzing model output.

During the Post Test Modeling Phase, model input parameters are carefully matched with field trial output values. Such factors as force size, terrain used, Ph and Pk data and system characteristics must be consistent in both the model and the field trial. The goal is for the model to replicate the field test events such as detections, engagements and movement rates. Once satisfied that the model matches the field trial as closely as possible, the simulation is run as many times as necessary to achieve the desired level of statistical confidence. In this manner any more "trials" are completed without the associated costs.

The final phase is Model Validation/ Accreditation. In this phase the modeler must provide sufficient evidence to the tester that the simulation adequately replicates the field experiment. This paper is intended to give the modeler some insights how to set up the model to achieve this goal [1].

3 Javelin Antitank System

This report focuses on the testing of the Javelin Antitank System. The Javelin will replace the aging Dragon System in U.S. Light Infantry units. It is completely man portable and constructed of rugged, lightweight composites. Although the exact value is classified, the Javelin more than doubles the range of the Dragon. Javelin uses a fire-and-forget technology where the gunner locks on the target before launch and does not have to guide the missile to impact, thus reducing his exposure time. The Javelin employs a top attack mode, striking targets in the least protected area, thus significantly increasing its lethality. Additionally the system has a tandem shaped charge warhead with demonstrated effectiveness against reactive armor [2].

4 TEC Instrumentation

TEXCOM Experimentation Center (TEC) operates a highly instrumented test range at Fort Hunter Liggett, California, where a large number of operational tests are conducted. During Force-on-Force battles, issues regarding a potential system's force effectiveness and tactics can be realistically examined under simulated battle field conditions. To control these engagements, TEC uses a computer to act as the field referee utilizing a system known as Real Time Casualty Assessment (RTCA). Since this study compares RTCA field trials to the same trials simulated in Janus, a brief discussion of how RTCA functions follows.

Field trial data to be used in MTM simulations comes from two categories of instrumentation: the Range Measuring System (RMS) and the Simulated Range System. MTM requires the position location for all systems that take part in the field trial and a corresponding time that the system was in that position. RMS is the most important position location system in RTCA to provide that information. It is composed of interrogator stations positioned at surveyed locations (A stations) and transponders located on the player system (B units). Through triangulation between several known locations, a range to the

player can be determined. The computer then can calculate player position as a function of time. The position location information along with the associated time that the system was at that location gives the modeler a timing sequence to reconstruct the movement paths that occurred in the field into the simulation. A graphical overview of the RMS operation is given in Appendix A.

The other instrumentation category of importance for MTM comparison is the Simulated Fire System. This system creates a simulated firing between live targets on the TEC battlefield and serves as a referee in determining casualties. Part of the Simulated Fire System, the Direct Fire System uses eye-safe lasers that are boresighted with the actual weapon system used in the experiment and laser sensors placed on each player. When a weapon is fired, the laser beam follows a straight line path to the target. If the laser beam has line of sight (LOS) with the target and strikes a sensor then a laser pairing or "detection" occurs. An information code is then relayed to the controlling computer which uses Ph and Pk tables to determine the probability that the target has been hit, killed or subject to a near miss. This casualty assessment information is relayed back to the player in almost real time. This casualty information is also essential in comparing the model simulation casualties to the field results. Further information regarding RTCA can be found in [3].

5 Terrain Effects

The Janus combat model uses a digitized terrain database utilizing the Defense Mapping Agency (DMA) Digital Terrain Elevation Data (DTED) Level I data. This Level I data is in the form of a profile plot which is converted into a contour plot in order to be used in Janus. For this research, the Fort Hunter Liggett Military Reservation terrain data was used. The Janus database allows various levels of terrain resolution from 25x25 meters to 200x200 meters. Within each cell is a representation of specific characteristics of the terrain including elevation, vegetation/urban, density and height, road data, rivers and trafficability [4]. Representative Janus terrain for Fort Hunter Liggett is shown in Appendix B. Appendix B also shows an example of how terrain features are represented for each grid cell.

Janus uses the terrain database for several of its calculations. A LOS algorithm essentially connects a straight line between the grid cells containing the observer (firer) and the target. Should there be any intervening grid cells with an elevation intersecting that line, then LOS does not exist. If LOS exists then a detection algorithm developed by the Night Vision and Electro-Optical Laboratory (NVEOL) is put into play. The NVEOL model is widely used in approved high resolution models, and uses the physics of the environment, to determine whether the observer in fact detects the target. Should a detection occur, the observer fires his weapon system. Janus then uses its look-up Ph and Pk tables to determine if the target is killed [5]. These tables also consider range and target aspect, which require special modeling considerations and will be discussed later in this report.

The terrain also plays a significant role for modeling movement within the simulation. The combatant's speed is determined by comparing terrain data stored in each grid cell. The difference in elevations between cells determines the speed while negotiating that defined slope. Additionally, vegetation and urban obstacles either slow or stop the vehicle. Similarly, Janus also degrades movement by minefields and water.

The terrain is a critical component in the MTM process because of its effects upon movement and LOS calculations. The necessity to closely align the model terrain representation with the actual test range terrain becomes critical in the Post Test modeling phase. Field test data as described above includes specific information regarding each detection that occurred during field trials. Detections serve as the basis for firing weapons at an enemy target since without a detection there will be no firing. Whether a system is killed within the model or in the field is determined stochastically depending upon the Ph/Pk tables and would not be expected to match exactly. However, the simulation must attempt to have detections occur at the same locations as in the field test to have the "opportunity" for a kill.

The MTM process must ensure that the model terrain grids match as closely as possible the actual continuous terrain. Current efforts using MTM for the Javelin Initial Operational Test and Evaluation (IOTE), used a 50 meter grid cell resolution within Janus [6], [7]. Calibrating model terrain with actual terrain can be achieved using several methods, depending upon the data available for specific terrain. As described in [6], a very precise terrain database called Pegasus was available from TEC, measuring terrain to better than 10 meter accuracy. The process was then to compare the Pegasus terrain to the Janus terrain and then produce a modified Janus database to run the simulations. For example, more than 25 Pegasus terrain cells would be located with a 50 meter Janus cell. The modeler would have to subjectively use an average value for the 25+ Pegasus cells in the single Janus cell. Without an existing terrain file such as Pegasus, the modeler must use a topographic map with divisions corresponding to Janus grid cells and then estimate elevation and vegetation values. Certainly this is a very subjective process, but obvious errors can be corrected making the Janus model more closely representating the actual terrain. Additionally, with sufficient time and the use of Global Positioning System (GPS) actual, field the ground verification of terrain features would greatly improve accuracy.

To improve Janus terrain for use in MTM, several modifications are suggested. The smaller the terrain resolution in the model, the more accurately the test data can be represented. This refinement can be obtained using the techniques described above. Vegetation plays an obvious role in LOS calculations and its height and density can be adjusted in Janus. An excellent description of Janus vegetation representation can be found in [8]. A polygonal representation of areas of vegetation is used in the current Janus 5.0 release. This improvement will greatly add to the accuracy of LOS calculations, since vegetation can now be placed in the model using polygons rather than squares. This allows a much more robust representation of actual vegetation features, but still must be field checked prior to modeling efforts in MTM.

6 Probability of Hit and Probability of Kill Values

Using MTM, it is critical that the model is using the same Ph and Pk values that were used in the field test. Generally, this is difficult to accomplish in pretest modeling, since the data to be used in the operational test are not yet available. The issue then is to ensure that the model has an accurate representation of Ph/Pk data in the Post Test phase. It is worth noting that once the test is completed, the data for the model must correspond with the test values and not updated values for the system. The goal is for the model to reproduce the

results of the test even if it does not reflect the current status of the tested system.

TEC obtains its Ph/Pk data from the Army Material Systems Analysis Agency (AMSAA) who is responsible for producing valid Ph/Pk sets for use throughout the Army. A typical request for the necessary information for the Javelin Operational Test is provided at Appendix C. Data follows the form specified in Table 1, which outlines the functions for which Ph/Pk must be obtained and the specfic requirements for each function. For example, there would be a Ph/Pk value for a range of 200 meters on a fully exposed, moving target with a target aspect of 90°. Similarly, data for all combinations would be within the Ph/Pk database. A separate data set also must be obtained for every system played in the field trial.

TABLE 1: TEC Ph/Pk Requirements

Function	Requirement
Range	100 meter interval (for Javelin)
Target Exposure	Hull defilade/Fully Exposed
Target Speed	Moving/Stationary
Target Aspect	30 degree intervals

This data is used to calculate whether a system has been killed during an experiment using the RTCA process described previously.

Janus also uses Ph and Pk data sets to determine hits/kills within the simulation. An example of these sets are provided in Appendix D. Table 2 lists the Janus data requirements for the same functions listed in Table 1. Again, Janus must have the appropriate table for every system played in the simulation.

TABLE 2: Janus Ph/Pk Requirements

Function	Requirement
Range	4 point approximation
Target Exposure	Hull defilade/Fully Exposed
Target Speed	Moving/Stationary
Target Aspect	Flank/Head On

By taking a four point approximation in range, Janus approximates the Ph/Pk distribution by four linear pieces. Calculation of a Ph/Pk at a specified range is then interpolated from those linear segments [9]. For example, if a weapon system has a Ph value of 0.95 at 500 meters, 0.80 at 1000 meters, 0.75 at 1500 meters, 0.60 at 2000 meters, and 0.50 at 2500 meters, Janus would represent this data as portrayed in Figure 1:

Comparing the data used for both the TEC and Janus inputs, it is noted that the requirements for target speed and exposure match exactly. These two data sets should therefore use the same values in both databases. However, there is a different treatment for range and target aspect. Given a maximum range of 2000 meters (exact Javelin maximum range is classified), the TEC database would have 20 data points, whereas the Janus database would have only five. Similarly, for Target Aspect TEC would use 12 and Janus only two. There is a great difference in the amount of data for these two functions.

The modeling implications of this difference are hard to predict. The modeler must be aware of this problem as a source of possible error. A sensitivity analysis should be conducted to get some idea as to the amount of discrepancy between the actual field data and the Janus replication of those trial using different values in the Janus data base. For example, if field trials occur only over a certain subset of ranges, perhaps the four data point approximation over that reduced range would yield better results rather than using the four points over the entire range.

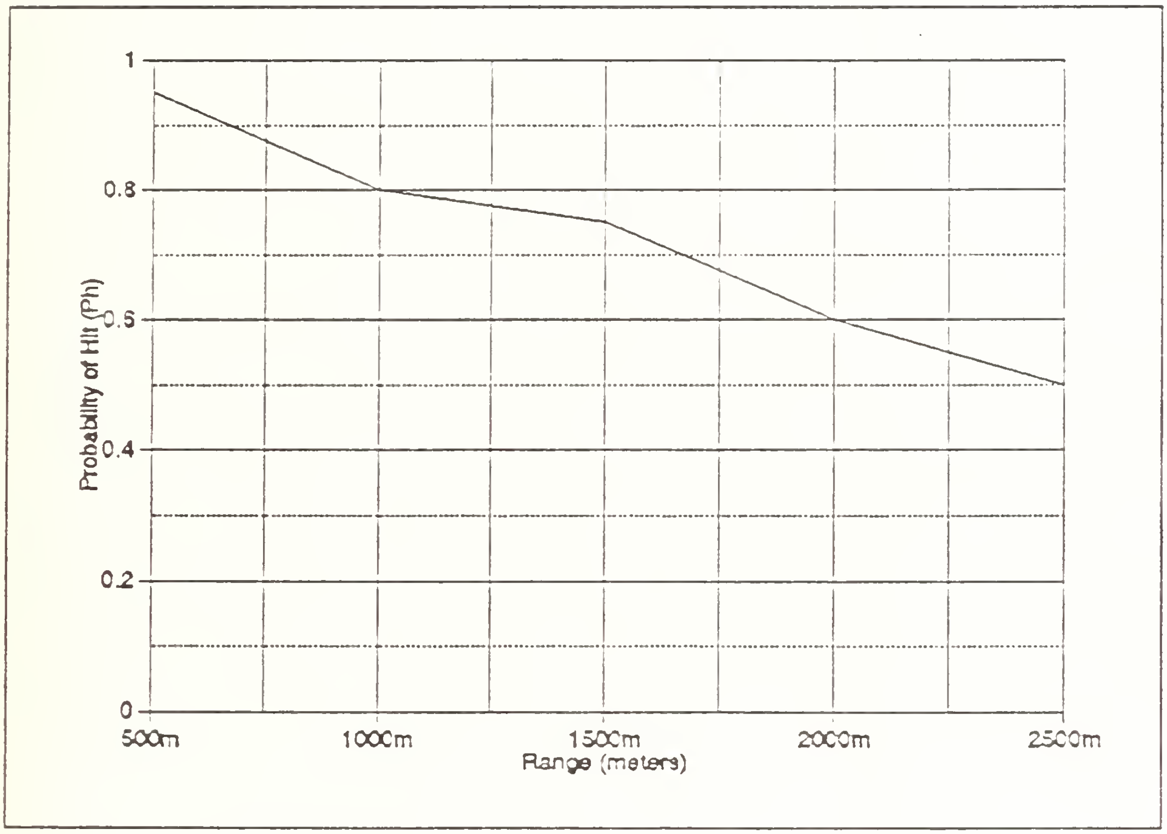


Figure 1. Janus P_h as a Function of Range

7 Modeling Modifications for Javelin

A model is an abstraction of reality and as such cannot perfectly recreate a weapon system. It is then the modeler's responsibility to attempt to best create that weapon within the structure of the model. Janus' relational database structure lends itself well to the modeling of new weapon systems. The Javelin system was constructed by first using the existing database values to reflect the Javelin's characteristics. Fortanbary [10, Chap 2] describes in detail the modeling of the Javelin.

Several of the improvements to the Javelin require further modification of the database to capture the full effect of those enhancements. Javelin uses a fire and forget missile. After the gunner fires the missile, he can take cover to protect himself from direct or indirect fire. Within the Janus structure, a system can not fire in a defilade position. To account for

this discrepancy, the enemy's Ph against the Javelin was reduced by 15% [7, p24]. Javelin's missile also uses a top attack method of engagement. Since this technique hits a tank or personnel carrier in an area with less armor protection, the Pk for Javelin against these systems is increased. This top attack method requires the missile to follow a flight path up to 100 meters above the ground, allowing the missile "to see" the target much better than the gunner at ground level. Janus uses an algorithm that causes the missile to miss if the gunner loses LOS with the targeted vehicle, where in reality the gunner does not need to have continuous LOS. Since the IOTE uses lasers which must have LOS for a pairing, Janus adequately captures the field test phenomena if not the actual performance parameter.

Usually any new system will require modification. It is essential that the modeler carefully record these values and provide a rationale as to why they were used. At a later date, better data can be entered into the database as it becomes available.

8 Conclusions

MTM appears to be a technique which can significantly improve test design and analysis. The model used must be carefully examined to insure that the field data can be adequately represented. This paper discussed the use of Janus(A) in replicating TEC field trials of the Javelin Antitank System. Several areas are of importance for future use of Janus in the MTM process. Terrain data must be scrutinized to minimize LOS problems due to vegetation and elevation data. Janus' Ph/Pk data must sufficiently capture the TEC lethality data. Finally, modeling modification must be documented to provide future users a starting point for continued use. Research by TRADOC Analysis Command-Monterey (TRAC-Mtry) is currently comparing Javelin IOTE field results to Janus model runs. A technical report describing these comparisons was recently published by Rolands and Associates titled "Posttest Modeling in Support of the Javelin IOTF Final Report" in August 1994.

9 References

1. Bundy, Dennis D., "Generic Model-Test-Model Using High Resolution Combat Models," TRADOC Analysis Command - Monterey, September 1993.

2. Department of the Army, Test and Evaluation Master Plan (TEMP) - Javelin, Javelin Program Office, Redstone Arsenal, AL, 10 October 1991.

3. Department of the Army, TEXCOM Experimentation Center, "Instrumentation Handbook, 2nd edition", Fort Ord, CA, 1985.

4. Department of the Army, TRADOC Analysis Command, "The Janus 3X/UNIX Model User's Manual," Fort Leavenworth, KS, 1993.

5. Hartman, J.K., Sam H. Parry, William J. Caldwell, Lecture Notes in High Resolution Combat Modeling, Naval Postgraduate School, Monterey, CA, December 1992.

6. McFadden, Willie J., Comparison of Janus(A) Simulated Terrain Vegetation Codes To Modified Terrain Vegetation Codes for the Javelin Antitank Operational Test, Master's Thesis, Naval Postgraduate School, Monterey, CA, September 1993.

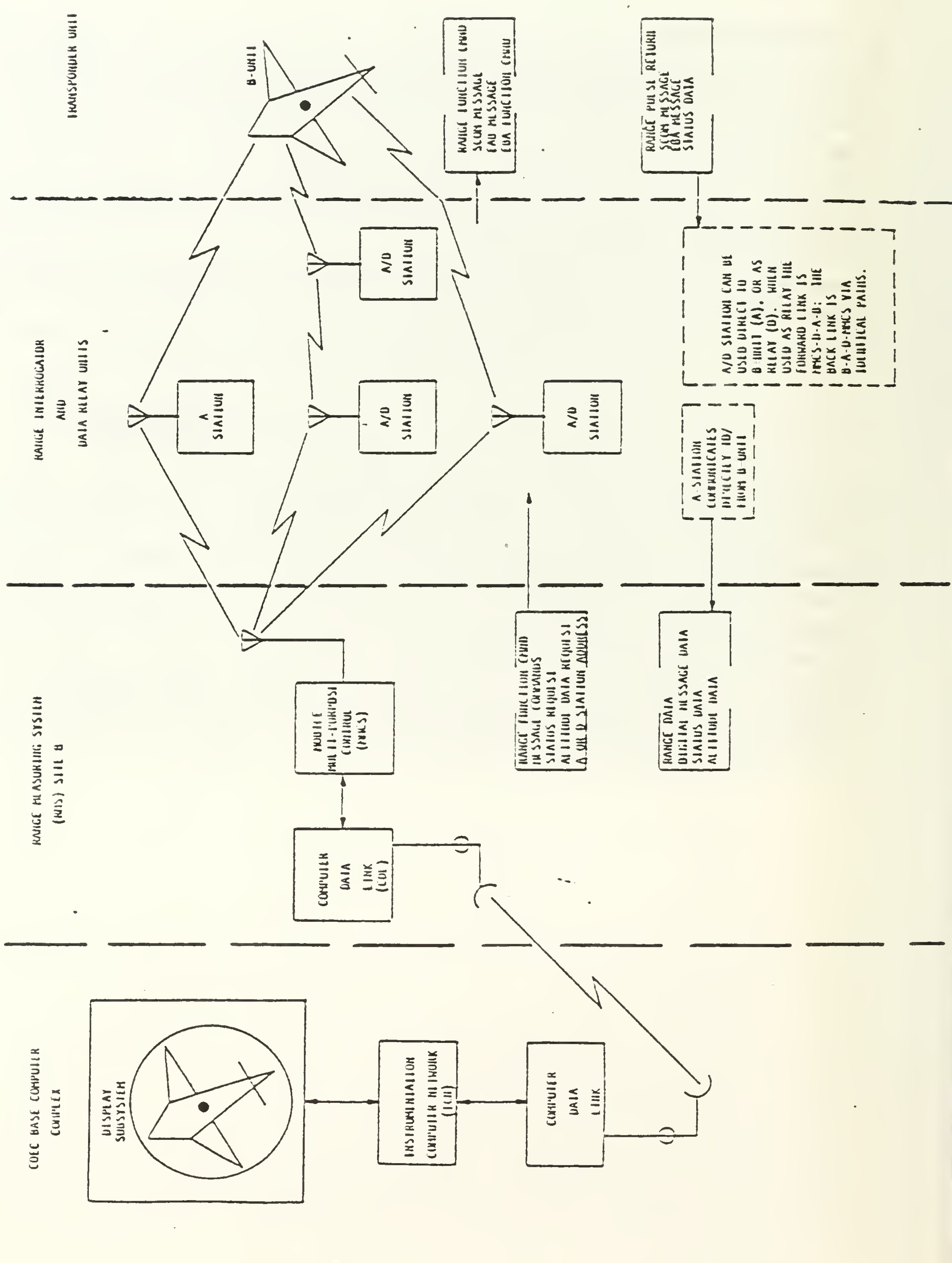
7. McGuire, Michael J., Javelin Vs. Dragon II: A Comparative Analysis, Master's Thesis, Naval Postgraduate School, Monterey, CA, September 1993.

8. Celski, Robert J., "A Study of the Line of Sight Calculations and Database for the Janus(A) Model," TRAC- MTRY, Monterey, CA, 1992.

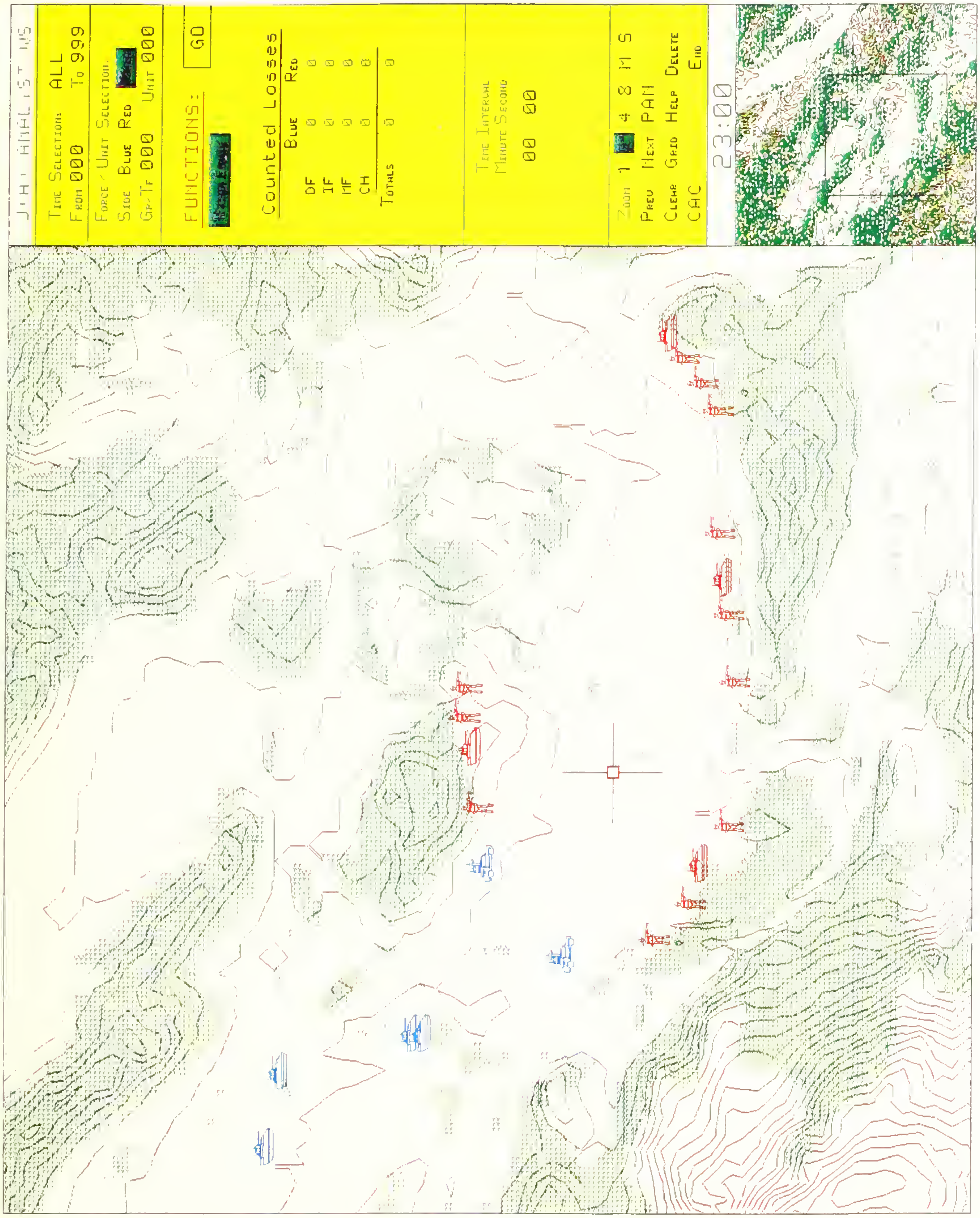
9. Hoffman, James and Bard K. Mansager, OA 4603 Test and Evaluation Laboratory, Naval Postgraduate School, Monterey, CA, pp. 1-58.

10. Fortanbary, Michael W., An Analysis of the Javelin Weapon System Parameters Using the Janus(A) Combat Simulation System, Master's Thesis, Naval Postgraduate School, Monterey, CA, December, 1993.

APPENDIX A: OVERVIEW OF RMS OPERATION



APPENDIX B: JANUS TERRAIN REPRESENTATION



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94 3 575.000000 7  0  0  0  0  0  0  0  0  0  0  0
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96 3 604.000000 7  0  0  0  0  0  0  0  0  0  0  0
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99 3 579.000000 7  0  0  0  0  0  0  0  0  0  0  0
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COLUMN	INFORMATION
1-2	Terrain Cell Identification
3	Elevation
4	Terrain Cell Vegetation Code

ANTI-ARMOR MISSILES

LETHALITY DATA REQUIRED FOR:

JAVELIN
DRAGON II
TOW IIA
AT4
LAW
SMAW
RPG-7V
VTT 323 AT-4

"Pks" required are :

infantry: Probability of hit
30 second assault incapacitation
30 second defense incapacitation.
vehicles: At least a firepower kill
at least a mobility kill
at least an M/F kill.
bunkers: Probability of hit on the bunker, expected casualties for personnel and weapons occupying it.
weapons: Probability weapon inoperable.
helo: At least mission abort.

Pks to be appropriately weighted (cardioid, close quarters ?).

Pks ARE REQUIRED AS FUNCTIONS OF:

1. Target type. See firer-target matrix

2. Range. From 0 meters to the maximum range of the missile at 500 meter intervals for the TOW and AT-4, and 100 meter intervals for the Javelin, Dragon, AT4, LAW, SMAW, and RPG-7.

3. Target exposure. Hull defilade and fully exposed for vehicles, prone and crouching for infantry.

4. Target speed. For Vehicles, stationary and moving where moving is defined as 20 kph. For helicopters, 20 m/sec Pk interval.

5. Attack mode. Top and direct (Javelin only).

6. Target Aspect. Thirty degree intervals (Javelin and Dragon only).

PROBABILITY of HIT Data Set: 0010

Posture	Range (m)-->	1	1000	2000	3000	4000
SSDF	-------->	0.70000	0.65000	0.50000	0.30000	0.20000
SSDH	-------->	0.60000	0.55000	0.40000	0.20000	0.10000
SSEF	-------->	0.90000	0.85000	0.80000	0.75000	0.65000
SSEH	-------->	0.80000	0.75000	0.70000	0.65000	0.55000
SMDF	--(not used)-->					
SMDH	--(not used)-->					
SMEF	-------->	0.80000	0.75000	0.70000	0.65000	0.55000
SMEH	-------->	0.70000	0.65000	0.60000	0.55000	0.45000
MSDF	-------->	0.50000	0.45000	0.30000	0.10000	0.01000
MSDH	-------->	0.40000	0.35000	0.20000	0.01000	0.01000
MSEF	-------->	0.70000	0.65000	0.60000	0.55000	0.45000
MSEH	-------->	0.60000	0.55000	0.50000	0.45000	0.35000
MMDF	--(not used)-->					
MMDH	--(not used)-->					
MMEF	-------->	0.60000	0.55000	0.50000	0.45000	0.35000
MMEH	-------->	0.50000	0.45000		0.35000	0.25000

NOTE: Defilade data not used when target is a flyer.

PROBABILITY OF KILL DATA SET: 0010

Posture	Range(m)-->	1	1000	2000	3000	4000
MOBDF	-------->					
MOBDH	-------->					
MOBEF	-------->					
MOBEH	-------->					
FRPDF	-------->					
FRPDH	-------->					
FRPEF	-------->					
FRPEH	-------->					
M/ DF	-------->	.75000	.70000	.60000	.40000	.05000
M/ DH	-------->	.50000	.45000	.35000	.30000	
M/ EF	-------->	.85000	.80000	.70000	.50000	.15000
M/ EH	-------->	.60000	.55000	.45000	.40000	
KK DF	-------->					
KK DH	-------->					
KK EF	-------->					
KK EH	-------->					

NOTE: At present, Only the four "M/" rows are used.

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